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CHANGES IN FOOD VALUE OF VEGETABLES DUE TO COOKING

A DISSERTATION

SUBMITTED TO THE FACULTY
OF THE GRADUATE SCHOOL OF ARTS AND LITERATURE
IN CANDIDACY FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

DEPARTMENT OF HOUSEHOLD ADMINISTRATION

BY

MINNA CAROLINE DENTON

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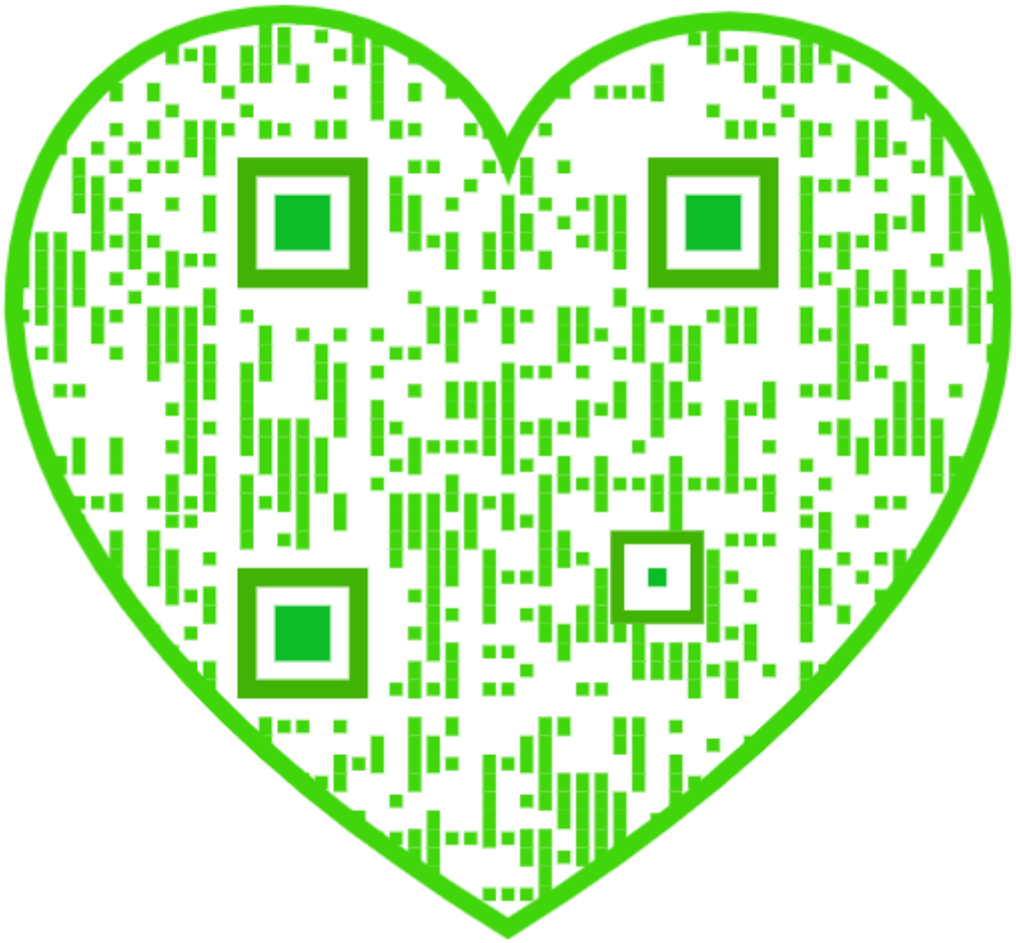

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CHANGES IN FOOD VALUE OF VEGETABLES DUE TO COOKING*

EFFECT OF VARYING HOUSEHOLD MANIPULATIONS

MINNA C. DENTON

I. INTRODUCTION

Recent progress in nutrition is emphasizing heavily the inadequacies of a diet with a preponderance of cereal products and vegetable fats—our cheapest sources of protein and calories—at the same time that food scarcity puts some of their most effective supplements, such as eggs, milk, meat, and animal fats, very nearly out of the reach of all except the well-to-do classes. It seems that many of the fresh vegetables and fruits have some value, in several respects, as supplements to inadequate diets of certain types. But at most seasons of the year these, too, are considered to be out of reach of the limited purse, with a few exceptions, prominent among which are vegetables which may be canned in time of plenty, and the "winter vegetables." If these local products are to be more largely used in the diet, both as supplements to the cereals and meats and as substitutes for them, an extended knowledge of their value with regard to various dietary factors is desirable. This study is concerned with the factors which are usually the first ones to be determined—their fuel values and ash content—these being determined from the vegetables as served to us at the table, after household manipulation, possibly also after commercial manipulation, as in the case of canned foods.

With the exception of potatoes, the winter vegetables are mostly strong-juiced or highly flavored, and their flavors do not commend themselves to all persons, particularly often not to those of highly discriminating or of irritable nervous organizations, unless the flavor can be somewhat modified. Partly for this reason and partly for purposes of convenience, the methods very generally employed in cooking and in canning them have involved the use of a greater or less excess of water, which has considerable extractive power at the temperatures employed.

* This paper was presented as part fulfillment of the requirements for the degree of Ph.D. in Household Administration, University of Chicago, August, 1918.

Food conservationists are urging that these vegetable foods should be baked, or steamed, or boiled in their jackets, or that the vegetable stock should be utilized; yet practical objections, such as those in the following list, continue to be urged upon some occasions.

1. It is apparent that neither cabbage heads nor large root stalks can be boiled whole,—their size forbidding this possibility.

2. Chlorophyl-bearing tissue usually turns more or less brown when steamed, though boiling water (even distilled, but especially when "hard" or when salted or made alkaline with soda) satisfactorily "sets" the green color of cabbage, cauliflower, Brussels sprouts, peas, string beans, and the yellow color of blanched celery. If the cooking be not too long continued, this green color is satisfactorily retained in boiled vegetables.

3. The steamed product is dryer and less water-logged than the boiled, and of different texture; it has of course no flavor of added salt, and yet (steamed at 90° to 100°C.) it may retain its characteristic odor and taste more strongly than does the boiled vegetable. The consequence is that the uninitiated frequently pronounce steamed cabbage both rank and insipid, also "not done."

4. The washing of spinach or greens which have been transported for long distances "packed in mud" (cracked ice) is a tedious process and often more or less of a failure, even when a good deal of pains has been taken. Under these circumstances it is a great help to boil in excess of water and skim out the greens when done, because thus the remaining sand and grit fall to the bottom of the kettle, instead of sticking to the leaves, as is the case with the steamed product.

5. The strong taste of condensed spinach juice, such as is produced by cooking the leaves in a very small amount of water, proves objectionable to many persons, including children not old enough to express themselves verbally upon the subject.

6. Baking is desirable, yet often impracticable for various reasons, among which are the expense of fuel, and the overheating of the kitchen from the oven.

7. Home and commercial canning methods alike usually call for a preliminary "blanching" process which is advisable for various reasons; yet this period of boiling in excess of water, which apparently is never utilized to advantage, seems inconsistent with our customary efforts to "save the juice." (This objection does not apply to the steam blanch or to blanching in skins.)

8. The vegetable canned in excess of water at high temperature, as are some of the commercially prepared products, may well lose a large part of its nutrient values of various sorts to the "juice" drained off when the can is opened; yet this juice, especially when excessive in amount, is often not palatable, and is feared by some because of its possible content in tin, lead, or iron salts derived from a metal container.

9. The cook often finds it a convenience to pare vegetables and cut them ready for serving, early in her preparation of the meal. She does not wish to add peeling of potatoes or carrots to the list of things which must be done in the busy period just before the meal is served when the biscuits are to be baked and the coffee to be put over, the gravy to be made, and the salad to be dressed. She therefore objects to cooking vegetables in their skins.

10. The use of a large rather than a small amount of water with vegetables shortens the period of their cooking to such an extent that the average home cook often prefers to use an excess of water rather than barely water to cover.

Thus it would appear that a single generalization does not suffice to dispose of all cases, but that the cooking of each vegetable is a question to be decided on its own merits, if the conservation of nutritive value is to be combined with maximum palatability and practical convenience.

Other questions which occur to the dietitian who compares the cooked vegetable with the raw, are such as these: After careful consideration of the details of every-day practice to be observed all about us, how are we to estimate the dietetic value of vegetables cooked in diverse ways? Shall we in computing or planning dietaries, assign to the cooked vegetable 90 per cent or 75 per cent or 50 per cent of the caloric value of the edible portion of raw vegetables? What is the proportionate loss sustained by vegetables which have been "blanched" in excess of unsalted boiling water, as practiced in some canning processes; by vegetables covered with water and cooked in quart jars in bath of boiling water for two and three hours, as recommended for home canning? Does the vegetable with high content of soluble carbohydrate lose proportionately more than that with lower content? Does the root stalk cut into large pieces suffer considerable loss? Do uncut vegetables which present a large amount of exposed cuticle (leguminous seeds, leaf greens, fleshy buds and flowerets as loose-leaved cabbage and cauliflower) suffer considerable loss from the extractive effect of boiling water? Are the losses from steaming at 90° to 100°C. (efficient home steamer) negligible; are

those from direct exposure to steam at 100° to 120°C. (institutional cooker) also negligible? Does the addition of salt to the cooking water, in small amounts (1.5 per cent solution at beginning of process) increase or diminish the cooking loss? Does the loss diminish if sectioning be done longitudinally (parallel with the fibro-vascular bundles) rather than crosswise (across them, exposing their cut ends at both surfaces of each slice to the solvent action of water)?

II. REVIEW OF LITERATURE ON LOSSES IN COOKING VEGETABLES

Most of the work done on losses of cooked vegetables is concerned chiefly with mineral constituents. In many cases very few details as to method of cooking are given, which makes it difficult to compare results of different investigators.

Wagner and Schaefer[1] reported finding that potatoes steamed in their skins lost 1.17 per cent of their crude ash, 0.69 per cent of their potassium, 0.03 per cent of their phosphorus. Steamed after paring, these losses were 7.28 per cent, 6.93 per cent, and 4.57 per cent, respectively. Boiled in their skins, they lost 3.64 per cent of their crude ash, 3.32 per cent of their potassium, 1.12 per cent of their phosphorus; boiled after peeling, 28.86 per cent, 38.33 per cent, and 22.87 per cent, respectively. 1 kgm. of spinach lost 8.578 grams of dry matter (1.684 gram N, 3.375 grams of ash); 1 kgm. of carrot tops, chopped, lost 15.252 grams dry matter (3.312 grams N, 6.331 grams ash). Average losses in boiling were 9 to 18 per cent of the total soluble matter found in the unboiled vegetable food.

Snyder, Frisby, and Bryant[2] found that potatoes when pared, soaked 3 to 5 hours, and put over to cook in cold distilled water, lost 46 to 58 per cent of their total nitrogen (about one-half of which is in the form of protein), 25 per cent of their protein, and 38 per cent of their mineral salts. When pared, put into either hot or cold distilled water, and cooked at once, the losses were half these amounts or less; when cooked in skins, the nitrogen loss was 1 per cent, the protein loss 0.5 per cent, the mineral loss 3.3 per cent. Frisby and Bryant, in another experiment, found that pared potatoes, put into cold distilled water and cooked, lost 9.2 per cent of their nitrogen, 2.7 per cent of their carbohydrate,

[1] Sachs, *Landw. Ztschr.*, vol. 33, p. 369, 1885. (Abstr. in *Jahresb. f. Agrikultur. Chem.*, N. F. 8, vol. 28, p. 443, 1885.)

[2] Bull. 43, Office of Exp. Sta., U. S. Dept. Agr., 1897.

and 17.2 per cent of their ash; when cooked in their skins, they lost 1.6 per cent of their ash. Varying the experiments by using "alkaline water" or "lime water," instead of distilled, produced no important variations in losses—except that it seemed that the lime water (and the cold alkaline water) took out a little more protein than did the distilled water controls. Carrots, scraped and cut into pieces, lost from 20 to 40 per cent of their nitrogen, and from 29 to 47 per cent of their ash, according to size of pieces. Half a solid cabbage, put into cold water and cooked, lost from 33 to 46 per cent of its nitrogen, 33 to 42 per cent of its fat and carbohydrate, 48 to 54 per cent of its ash; put into hot water and cooked, the losses were usually (but not always) a little less. On the whole, the alkaline and lime waters had a slightly greater extractive action than did the distilled water.

Kraus[3] found that cabbage turnip when cooked had lost 20 per cent of its carbohydrate; cauliflower, 33⅓ per cent; spinach, 71 per cent; winter cabbage, 53 per cent.

Zschokke[4] worked on losses in "blanching" (boiling in hot water) of carrots (cut in pieces), peas, string beans cooked whole and also cut into pieces. In each case, one-half of the vegetable was steamed and the other half boiled for 25 to 30 minutes. The losses in total dry matter were about five times as much by boiling as by steaming; losses in salts, usually only from three to four times as great in boiling as in steaming. He gives no data for raw foods, but, if we were to judge from American analyses for these foods, we should conclude that his losses in protein and mineral salts were markedly lower than those reported by most workers, while his losses in "nitrogen-free extract" run only a little lower than some losses in caloric value reported in the present paper. (He found a loss of 3.43 grams of nitrogen-free extract per 100 grams raw material in boiled carrots, 2.43 grams in boiled peas, 0.624 grams in beans boiled whole, 0.768 gram in beans boiled in pieces.)

Haensel[5] reports a loss of about 0.08 gram of iron oxide from 100 grams of fresh vegetable, in boiling spinach; and 70 per cent of its iron, in boiling lettuce in water—if I have correctly interpreted his report.

Williams[6] gives a number of analyses of cooked foods, calculated to moist condition; but in her earlier articles, no corresponding analyses of

[3] *Ztschrf. f. Diät. u. physik. Ther.*, vol. 1, p. 69, 1898. Cited in Hutchison's Food and Dietetics.

[4] *Landw. Jahrb. d. Schweiz.*, vol. 19, p. 615, 1905.

[5] *Biochem. Ztschr.*, vol. 16, p. 9.

[6] *Jour. Amer. Chem. Soc.*, vol. 26, p. 244, 1904.

raw materials were made, so that it is impossible to judge of the proportionate losses. A later article[7] reports a loss of 10.59 per cent of its protein and 5.36 per cent of its ash, by celeriac, pared, sliced thin, and cooked 30 minutes in boiling water. Chicory, borecole, and endive (procedure not stated) lost from 30 to 43 per cent of their protein and from 12 to 19 per cent of their ash. Dried legumes (butter beans, green flageolets, soy beans), soaked 12 hours and then cooked (whether in the same water, and how much, is not stated), lost into their cooking water 26 to 28 per cent of their protein, and 5.5 to 17.05 per cent of their ash. Chestnuts (evidently fresh) lost 54 per cent of their protein and 7 per cent of their ash. A still later paper[8] evidently reports further work, especially with regard to protein losses. Cooked in boiling water by the usual method, spinach, with 10 per cent of total solids, loses one-fourth of these; celeriac loses half of its total solids (7 per cent of its ash, 54 per cent of its protein); turnips, almost half; lettuce, one-fourth; asparagus, one-sixteenth; curly greens (borecole) 40 per cent (16 per cent of its ash, 54 per cent of its protein); chicory, 20 per cent (12 per cent of its ash, 43 per cent of its protein); butter beans, 10 per cent (19 per cent of its ash, 30 per cent of its protein); endive, 25 per cent (19 per cent of its ash, 30 per cent of its protein).

Furthermore, Miss Williams gives the following analyses, together with those of many other foods, in a table in the Appendix of the third volume of Van Noorden's *Metabolism and Practical Medicine*, 1907. It is not stated, whether all of the analyses represent original work, or whether some of them are compiled from the works of others. No details as to cooking procedure are given. Apparently the analyses for the raw vegetables are not intended as strict controls for those upon the cooked samples; rather, each represents a sample picked up more or less at random. Indeed, the editor's note states that in many cases these figures must be looked upon as merely illustrative, rather than as the basis for generalizations. It is therefore hardly possible to compare these results with those given in Tables I and II of this paper.

These items have been rearranged alphabetically and also so as to places figures for *raw* and *cooked* samples side by side, instead of having them in different tables, as they were printed in the Van Noorden text.

[7] *Jour. Indust. Eng. Chem.*, vol. 5, p. 653, 1913.
[8] *Chem. News*, vol. 113, p. 143, 1916.

Analysis of raw and cooked vegetables

VEGETABLE	PROTEIN (N X 6.25)		ASH		CALORIES PER 100 GRAMS	
	Raw	Cooked	Raw	Cooked	Raw	Cooked
	per cent	*per cent*	*per cent*	*per cent*		
Asparagus	1.8	2.1	0.7	0.7	22.7	18.1
Artichoke, green	4.8	2.9	1.6	1.1	72.4	45.3
Artichoke, Jerusalem	2.0	1.8	1.1	0.6	71.8	27.1
Beans, haricot (dried)	23.0	4.6	3.2	0.7	344.4	60.7
Beans, scarlet runner	2.3	1.8	0.8	0.4	42.4	17.4
Beetroot	1.6	0.4	1.1	0.4	47.2	14.1
Broccoli	3.8	2.5	0.9	0.6	33.2	22.6
Brussels sprouts	1.5	2.8	1.3	0.5	17.9*	30.1
Cabbage, savoy†	1.5	0.6	1.2	0.1	34.5	4.6
Carrots	0.5	0.5	1.0	0.1	6.7*	16.7
Cauliflower	1.8	0.9	0.7	0.2	31.2	6.2
Kale (sea-kale)	1.4	0.4	0.6	0.2	21.1	3.7
Leeks	1.2	1.4	0.7	0.8	23.3*	38.6
Lentils (dried)	24.2	8.8	2.6	0.7	368.8	121.9
Onions	1.5	0.1	0.5	0.1	28.4	4.2
Parsnips	1.6	0.2	1.4	0.1	82.5*	8.2
Peas, (dried)	21.0	9.4	2.6	0.7	329.9	139.7
Peas, green	7.0	2.8	1.0	0.3	102.7	30.6
Potatoes, boiled in skins	2.1	1.6	0.7	1.3	109.5	84.1
Potatoes, boiled after pared	2.1	1.6	0.7	0.7	109.5	78.5
Spinach	2.1	0.3	2.1	0.2	24.4	2.9
Turnips	1.3	0.3	0.8	0.3	36.1	4.6
Vegetable marrow	0.6	0.1	0.5	0.1	14.8	0.8

* Evidently a misprint, for this number does not correspond to the analysis for protein, fat, and carbohydrate printed in the table from which this is an abridgment.

† It is not clear whether the raw and cooked cabbage were from the same or from different varieties.

Maurel and Carcassagne[9] found that blanching for 30 minutes (or 15 minutes? the two reports conflict) in distilled water, removed 40 per cent of the total salts from cauliflower, 44 per cent from Brussels sprouts, 55 per cent from cabbage sprouts, 26 per cent from celery root (celeri pied), 37 per cent from celery leaves, 35 per cent from asparagus, 34 per cent from green beans, 19 per cent from white beans, 33 per cent from lentils, 61 per cent from potatoes. Amounts of potassium lost were in all these cases, except two, relatively high, ranging from 25 to 73 per cent of total potassium. In general, 40 to 50 per cent of total salts (50

[9] *Compt. rend. Soc. Biol.*, vol. 67, p. 91, 211, 1909.

to 75 per cent of total potassium) was lost in this blanching process. In the case of legumes, 30 minutes' blanching removed a much larger amount of potassium (73 per cent in white beans, 38 per cent in lentils) than did the remainder of the three hours' cooking (16 and 22 per cent, respectively). These authors also quote Laborde[10] as finding a loss of 75 per cent total salts (60 per cent of potassium) in the blanching of cabbage; and Labille[11] as reporting losses of 29, 70, and 54 per cent of total potassium for 5 minutes' blanching of green beans, sorrel, and spinach, respectively; also, loss of 36 per cent of potassium in 10 minutes' blanching of potatoes.

Poppe[12] cooked (or soaked) fresh green peas in two and one-half times their own weight of water or liquid, for 1 hour at 100°C., for two hours at 50°C., for 24 hours at 20°C. They used seven liquids—distilled water, saturated NaCl solution (56 per cent), half-saturated, and quarter-saturated (10 per cent NaCl), saturated sugar solution (about 105 per cent), half-saturated, and quarter-saturated (18.4 per cent). They found that the peas boiled in distilled water lost 10 per cent of their nitrogen (it seems the raw peas contained 19 per cent of protein), 13.6 per cent of their carbohydrate (6.92 per cent carbohydrate in raw peas), 3.9 per cent of their phosphorus (0.66 per cent in raw peas), none of their chlorine. The salt solutions removed less of the nitrogen than did distilled water, and very little phosphorus or carbohydrate; the stronger salt solutions removed less nitrogen, in general, than did the weaker, but there was little difference in their extractive effect on carbohydrate. All losses were, as a rule, greater at the higher temperatures, because these kill the protoplasm and convert it from a semi-permeable membrane to a permeable one, whereas at 20°C. the living protoplasm, though it imbibes water, is able to regulate its loss of solutes and the entrance of solutes from its environment, to a considerable degree. The peas took up about 1 per cent of their own weight in salt from the boiling quarter-saturated salt solution, and about 1.5 per cent of their own weight of sugar from the boiling quarter-saturated sugar solution. It is not stated whether the solutions were kept at their original strength by renewal of water as they boiled, or whether they became more concentrated as cooking proceeded. Unfortunately these most careful and scientifically made observations can apply only somewhat remotely to

[10] *Soc. d. Hist. nat. Toul.*, March 28, 1900, p. 67.
[11] *Traite de l'Alimentation*, vol. 3, p. 522, 44, 35.
[12] *Bul. Soc. chim. Belg.*, vol. 25, p. 136, 1911.

the problem of cooking losses, since solutions as strong as these could not be used in preparing vegetables.

Berry[13] found that boiled spinach lost 50 per cent of its salts; boiled cabbage 40 per cent; boiled carrots (cut in pieces) 11.5 per cent of their salts (23 per cent of phosphorus) and 26 per cent of soluble carbohydrate.

Berg[14] suggests that in some cases the losses in alkali as a result of boiling vegetables are so great that the vegetable may actually lose its basic ash, and come to possess an acid ash.

Bodinus[15] announces that the loss of solids in boiled potatoes is at least 2 per cent if pared. If sodium chloride be added to the water, the loss is 1.25 per cent of the starch and 10 per cent of the potato salts; if no salt is added, the potato loses 33 per cent of its salts.

Morgan[16] reports a smaller loss of salts in peas canned by the commercial process than in those canned by the three-day sterilization home process. (Specifications and detailed results not given.) She found a loss of 18 per cent of the ash (25 per cent of phosphorus) due to blanching.

Blunt and Otis[17] boiled 5 to 10 grams of spinach, string beans, navy beans, and peas, respectively, in 25 to 75 cc. distilled water in a covered beaker for 20 to 40 minutes (navy beans two hours); potatoes were also boiled (seven were scraped, cooked together, and mixed). These vegetables, both raw and cooked, and the cooking water were then analyzed for iron. The losses found were: spinach, between 43 and 50 per cent of its total iron; string beans, between 39 and 43 per cent; navy beans, between 32 and 39 per cent; peas, 36 per cent; potatoes, between 15 and 22 per cent.

Visawanath[18] found that neutral salts (of calcium, magnesium, and sodium) retard, and alkaline salts (e.g., Na_2CO_3) accelerate the cooking of legumes (dhall) because they retard or accelerate respectively, the solution of protein and starch, but more especially of protein.

Courtney, Fales, and Bartlett[19] cooked seven varieties of vegetables by "thorough boiling" for 30 to 150 minutes, and analyzed cooked vegetables and cooking water for calcium, magnesium, phosphorus, chlorine,

[13] *Jour. Home Econ.*, vol. 4, p. 405, 1912.

[14] *Nahrung. u. Genussmittel, Aschbestandteile*, Dresden, 1913.

[15] *Chem. Zentr.*, Bd. 2, p. 37, 1915.

[16] *Jour. Home Econ.*, vol. 7, p. 72, 1915.

[17] *Jour. Home Econ.*, vol. 9, p. 213, 1917.

[18] Mem. Dept. Agri., India, Chem. Ser. 4, No. 5, p. 149, 1916. Abstr. from *Chem. Abstr.*, 1917.

[19] *Amer. Jour. Dis. Children*, vol. 14, p. 34, 1917.

potassium, sodium, sulphur, iron, and nitrogen. The percentage losses on most salts were greater than losses in calcium and nitrogen. New Zealand spinach was an especially heavy loser (72 per cent of total ash), yet it lost very little of its calcium, and the same thing was true of ordinary spinach. (Both these vegetables are especially good sources of calcium, if one were to judge from chemical analyses alone,—a questionable proceeding.) Carrots, onions, and asparagus lost but a trace of iron; spinach, 28 per cent of its iron; New Zealand spinach 51 per cent. Reducing the time of cooking made little difference in the losses (spinach cooked 10 minutes instead of 90, string beans cooked 60 minutes instead of 150 minutes lost almost as much as before). Steaming, however, reduced the losses materially (spinach only half as much loss as when boiled, asparagus one-third as much, carrots one-fourth as much). New Zealand spinach and onions still lose 20 to 30 per cent of their more soluble constituents, when steamed (for 30 minutes).

Weibull[20] concludes that while potatoes do not lose appreciably if boiled in their skins, they lose 0.5 per cent of their solids if pared before boiling. If sweetened by chilling, they lose 0.5 per cent when boiled in skins, 1.5 per cent when pared before boiling. Cooked in hard water, they retain their solanin; cooked in distilled water, they lose one-third of it.

Wardall,[21] working to develop a method of making vegetables free of digestible carbohydrate for the use of the diabetic, placed the finely cut vegetables in cold water, brought this to the boil, boiled for several minutes, then poured the water off and repeated the process. She found that, while beets give a test for reducing sugar after two such extractions and are then exhausted of such carbohydrate, cabbage still gives the test after 8 extractions, carrots after 6, eggplant after 7, parsnips after 6, pineapple after 9. Extracted in water at 60°C., 1 hour was required to extract all reducing carbohydrate from beets; $1\frac{1}{2}$ hours for carrot; 2 hours for eggplant; 1 hour for parsnips; $3\frac{1}{2}$ hours for pineapple. Cabbage seemed to give up little of its reducing substance to a 60°C. extraction.

[20] *Kungl. Landtbruks-akad. Handling ar Tidskrift*, vol. 56, p. 348, 1917. Abstr. in *Chem. Abstr.*, 1917.

[21] *Jour. Amer. Med. Assn.*, December 1, 1917.

†Masters[22] tried the effect of boiling dried beans in a large excess of water (five times their own weight) treated in various ways. She found that soaking the beans overnight reduced the time of cooking only from 2 hours and 5 minutes to 2 hours. (The experience of the author of this paper is very nearly in accord with hers, though there is a good deal of variability among the different kinds and different grades of maturity. If the beans be put directly into boiling instead of into cold water to cook, the time is still further reduced in some instances.) The soaked beans lost a larger proportion of their solids than did the unsoaked (12.2 per cent instead of 10.5 per cent in tap water; 12.6 per cent instead of 11.1 per cent, in distilled water). Salting the water reduced the losses considerably: in 0.25 per cent NaCl, they lost 9.2 per cent of their solids; in 0.5 per cent NaCl, 8.7 per cent; in 1 per cent NaCl, 8.3 per cent. Even the salts of tap water had a slight effect in this respect (11.1 per cent loss when boiled without soaking, instead of 10.6 per cent loss in tap water), when soaking and cooking were not too much prolonged. Adding soda increased the losses; boiled (without soaking) in 0.1 per cent solution of sodium bicarbonate in tap water, they lost 11.3 per cent of their solids; in 0.25 per cent solution, 14.3 per cent; in 0.5 per cent solution, 22.3 per cent; in 1 per cent solution, 27.3 per cent. Disintegration was very rapid at the higher concentrations, and the flavor was such that the beans were uneatable; the most satisfactory results were those when 0.1 per cent sodium bicarbonate was used.

Cooking by steaming was also tried; 100 grams beans were covered with 250 grams boiling water, the basin was placed quickly in a steamer, and closed with a tightly fitting lid. When thus steamed without previous soaking, they lost 8.9 per cent of their solids; soaked overnight and thus cooked, they lost 10.4 per cent; cooked (without soaking) in 0.25 per cent NaCl, they lost 8.4 per cent; cooked (without soaking) in 0.1 per cent sodium bicarbonate and 0.25 per cent salt, they lost 7.8 per cent; cooked in 0.1 per cent soda and 0.25 per cent salt after previous soaking they lost 8.1 per cent of their original weight.

Denton and Kohman[23] fed young white rats raw carrots, boiled carrots with the concentrated cooking water, boiled carrots without

† This thesis was prepared in March 1918. The following notes were added in March, 1919, in order to bring the bibliography up to date.

[22] *Biochem. Jour.*, Oct., 1918.

[23] *Jour. Biol. Chem.*, vol. 36, p. 259, November, 1918.

the cooking water, and canned carrots (processed two hours in boiling water bath). During the short period (five weeks) when carrots formed the sole diet (except for certain salts which were added), it was clear that those animals fed on raw carrots had the advantage over the others. Difficulties which the animals had in accommodating themselves to the unsuitable diet appeared to be greater, in proportion to the length of time the carrots had been cooked. However all animals rallied and began to improve in time, except those on the canned carrots, who were started later than the rest and had not sufficient time to show what they could do before a change in diet was made. When protein, fat, and starch were added to the diet in such proportions that the carrots furnished only one-half to two-thirds of the solids and of the calories of the diet, cooking of the carrots seemed to have no deleterious effects. True, however, it was observed that those animals which received carrots with the concentrated juice cooked down to some degree of caramelization did, after a time, fall considerably behind the rest in food consumption and also somewhat in rate of growth. The reason for this difference, which was perfectly apparent to all those who handled the animals and their food, cannot be stated, so far as I know, at the present moment.

Those animals fed boiled carrots without the juice, on the other hand, developed unusually large appetites, though their growth curves were not quite as good as those of animals similarly fed on raw carrots. Presumably this shows the effect of the loss of a considerable portion of the caloric value of the vegetable into the cooking water.

Daniels and McClurg[24] fed young white rats on a diet in which cabbage (raw, or boiled in water or in soda and water, or autoclaved) was the only source of water-soluble vitamine. The cooking water was inclued in the diet in all cases. If my method of figuring this dietary is correct, the cabbage of these diets furnished 15 per cent of the calories; 250 grams of cabbage were used to 100 grams of dry ration (casein plus starch plus salts plus fat). The soda was added in the proportion of $1\frac{1}{3}$ teaspoons per cup of raw beans (33 cc. of 5 per cent solution of sodium bicarbonate to 50 grams of soy beans); and $1\frac{1}{3}$ teaspoonful to 1 pound of cabbage (63 cc. of 5 per cent solution, to 250 grams cabbage); this proportion of soda is about what is very commonly used in cooking these vegetables. Their experiments continued only through one month

[24] *Jour. Biol. Chem.*, vol. 37, January, 1919.

in the case of cabbage feeding; but it is believed that the effects of a decided deficiency of water-soluble vitamine should be apparent within that time. Yet animals on all of these cooked diets throve equally well with those fed raw cabbage, and all animals kept pace with or exceeded the normal rates of growth. Evidently, then, cooking of cabbage even at high temperatures or even in alkaline medium did not sufficiently impair the water-soluble vitamine so that growth was perceptibly interfered with, under the conditions above described.

It must, however, be noted with respect to the last two investigations reported, that it is possible the results might have been slightly different if the amount of vegetable fed had been reduced to the minimum, or that which would furnish barely sufficient vitamine to meet the needs of growth. In case cooking does have a slightly prejudicial effect on vitamines, it would be more likely to appear when the margin of safety is a narrow one than when it is a very wide one. It may be added, that the amounts of vegetables fed (especially in the carrot diets) in the diets described above are larger, proportionately, than is usually considered possible in human dietaries. Even in the case of the cabbage diets, it will be observed that the vegetable furnishes 15 per cent of the calories; this would call for 2.45 pounds edible portion, or 2.91 pounds of cabbage as purchased, in the 2500-calories-a-day dietary; or 2.94 pounds edible portion, or 3.48 pounds as purchased, in the 3000 calorie diet of man.

As Miss Daniels remarks, this excessively wide margin of safety in respect to vitamines may perhaps account for the fact that her results are different from those of McCollum and co-workers (Jour. Biol. Chem., Vol. 33, p. 55) who found that the water soluble vitamine extracted from the wheat embryo was apparently destroyed by 60 minutes boiling in alkaline medium.

Stanley[25] gives tables showing losses due to blanching varying from 19 per cent in wax beans to 53 per cent in cabbage. Another table shows 52 per cent of mineral matter lost in boiled spinach, 9 per cent in steamed; 41 per per cent in boiled cabbage, 11.5 per cent in steamed. Details of manipulation are not given.

III. PURPOSE OF THIS INVESTIGATION

This work was undertaken with a view to determining how great are the variations in food value resulting from different methods of house-

[25] Cooking of Vegetables. Cir. 1, Agr. Ext. Service, Univ. of Mo., 1915.

hold manipulation, in any given process of cooking. The process most frequently studied was that of boiling vegetables. The details considered cover such points as those mentioned on page 3 of the introduction.

IV. METHODS

The methods which were used by the writer in cooking these vegetable samples are described in the tables given below. After cooking, the vegetable was ground or mashed or thinly sliced into lead caps or on to glass plates, and dried at 30° to 80°C. in an oven, or warm air blast, or over a water bath. The amounts of vegetable cooked were ordinarily between 50 and 100 grams, or often much more. This amount was necessary in order that the process should have some resemblance to the ordinary household process; also, in order to secure an approach to homogeneity of samples. After drying, the samples were finely ground for burning in the bomb calorimeter. Often they were formed into pellets by hammering against a metal rod in a metal tube. This was done in order to prevent scattering when the first rush of oxygen enters the bomb; usually, however, this precaution was unnecessary.

The control (uncooked vegetable) was always taken from the same lot as were those that were cooked. As individual specimens, even from a given lot, may often vary considerably among each other in water content and consequently in percentage composition, the control was, whenever possible, a part of the same individual vegetable specimen. In cutting the samples used as controls (uncooked), pains was taken to secure strips running lengthwise through every region of bud or root-stock, so that proportionate amounts of cortex, pith, fibro-vascular bundles, parenchyma, or growing region, would be about the same in control as in other samples. Where it was necessary to take transverse sections, these were selected alternately from the various regions, so that each sample might contain representatives or every region.

Combustion was conducted in a platinum or nickelled capsule, by means of a Riche adiabatic bomb calorimeter (vacuum insulation; ignition by means of linen thread instead of iron wire was frequently used). A differential thermometer was read so as to show differences in temperature of 0.001°C. Bomb calorific values are thus obtained directly, for the dried material.

It is not practicable to give calorific values in terms of weight of cooked vegetables, since this weight varies enormously according to the

details of manipulation, and varies, indeed, from moment to moment as the steaming vegetable cools and loses water. I have therefore calculated all values for cooked vegetables upon the basis of raw weight. For example, suppose that 100 grams of raw parsnips weigh 95 grams after cooking (at the moment of manipulation), which dry down to 20 grams; and that this dried parsnip shows a caloric value of 4000 (gram-calories) per gram. Then the raw vegetables with a corresponding value should be assigned 20 per cent of 4000 calories, or 800 gram-calories per gram; which is 363 kilo-calories per pound. If the control or uncooked parsnip shows a value of 1000 gram-calories per gram of fresh vegetable (or 454 kilo-calories per pound), then it is evident that this parsnip has lost 20 per cent of its caloric value in the cooking process.

Duplicate samples taken from the same vegetable specimen (or from the same lot if of very small size, as peas) should check within 2 or 3 per cent at farthest. A closer check (0.5 per cent) is usual, but not always possible with raw vegetables, because of the lack of homogeneity of the material. When a high salt content (spinach, some beans) interferes with complete combustion in the calorimeter (by the fusing of salts so as to encase carbon particles and protect them from combustion), the difficulty may sometimes be remedied by spreading the dried powdered sample over a piece of filter paper, whose dry weight and caloric value per gram are known, rolling the whole like a cigarette and bestowing it in the capsule for combustion. Substracting the calories due to the filter paper, one has then left the calories due to the dried vegetable. Usually, however, if the linen thread (instead of the iron wire) be used for igniting, there is no difficulty.

Furthermore, the calorie value of the total cooked sample plus the calorie value of the concentrated cooking water must be approximately equal to the calorie value of an uncooked sample of the same size, as calculated from the control. This check was conducted in a number of instances (though by no means in case of all samples reported) by evaporating the cooking water to a few cc. of sirup, taking it up on a weighed piece of filter paper of known calorific value, drying and burning the whole mass together, or in fractions, as might be necessary. In those cases where the amount of extract is too great to be concentrated into a volume convenient for such a test, it may be dissolved in a relatively large volume of water (e.g., 100 to 250 cc.), mixed until thoroughly homogeneous, and divided into aliquot portions in any convenient

manner. One of these portions is then concentrated, collected, dried, and burned as above. Any suspended particles must be allowed to settle, and then be filtered out of the whole sample before division into aliquots, finally to be dried and burned separately.

Doubtless the question will suggest itself, why should so large a percentage of these determinations have been made with carrots and parsnips? The reasons were that their cheapness (price per pound) and the ease with which they are stored have put them into general use; that they are usually pared and cut before cooking, largely as a matter of convenience to the cook; that their high sugar content makes them sensitive indicators upon which the effect of varying manipulations may be detected.

Total salts were determined by the water-leaching method (Official Methods, Association Official Agricultural Chemists, Bureau of Chemistry, Bulletin 107); ignition in muffle furnace.

VI. DISCUSSIONS AND CONCLUSIONS[26]

1. The vegetables experimented on, when boiled until tender in excess of water which is thrown away, lose from 15 to 60 per cent of their fuel value. (It is a very simple matter to demonstrate these losses ocularly, by cooking pared parsnips, pared carrots, some varieties of peapods, cabbage, onions, etc., finely cut or even coarsely cut, in plenty of water, and then concentrating this water, after pouring off, to small bulk, when it takes the form of a molasses.)

The losses are, of course, less, proportionately, when there is less soluble matter to lose. Turnips, cabbage, cauliflower, young carrots, asparagus, onions, spinach, peas, string beans, lose less than do parsnips and mature sweet carrots and Brussels sprouts (compare C III, 2, also C IV, 3, with C I and C II). Apparently carrots have their carbohydrate more largely in soluble form, than do parsnips, for their losses are proportionately heavier, under the same treatment, especially in those cases where their calorie values at all approach those of parsnips. (See P II, 6 and C I, 6.)

2. The losses in salts in every case except one (Spinach I, 2 steamed) parallel the calorie losses, and usually rather closely. They are, as a rule, slightly greater than the calorie losses. (The same thing was true of nitrogen losses, in those cases where such determination was made.)

[26] References are to table 1, unless otherwise stated.

TABLE I

Losses in cooking vegetables, caloric values

SERIAL NUMBER	MANIPULATION	WEIGHT 100 GRAMS RAW VEGETABLES AFTER BEING COOKED AND DRIED	CALORIE VALUE PER GRAM OF DRIED VEGETABLES	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER GRAM OF RAW WEIGHT	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER POUND OF RAW WEIGHT	CALORIFIC MATTER LOST IN COOKING
Peas, I. Young green, purchased May 9, 1917; pods well filled, peas quite juicy						
		grams	*gram-calories*	*gram-calories*	*kilo-calories*	*per cent*
Peas I, 1	Uncooked.*	25.50	4102	1044	473	
Peas I, 2	82 grams vegetable blanched 4 minutes in 400 cc. salted distilled water (1.4 per cent); cold-dipped under running tap. Then placed in 80 cc. boiling salted distilled water (1.5 per cent); boiled twenty minutes; peas had taken up all the water. Washed in 90 cc. distilled water, brought to boil in four and one half minutes, then drained off. Weight, after cooked, 90 grams.	24.97	4139	1033	469	0.8
Peas, II. Young green, purchased June 5, 1917; pods filled with varying sized peas, some large ones						
Peas II, 1	Uncooked.*	26.16	4249	1112	504	
Peas II, 2	102 grams raw vegetable blanched six minutes in 500 cc. boiling distilled water; cold-dipped under running faucet. Weight, after cooled, 106 grams.	21.99	4270	939	426	15
Peas II, 3	115 grams raw vegetable blanched six minutes in 500 cc. boiling salted distilled water (1.4 per cent); cold-dipped. Weight, after drained and cooled, 111 grams.	24.4	4212	1028	466	8
Peas II, 4	103 grams raw vegetable blanched six minutes in 500 cc. boiling tap water; cold-dipped. Drained, and cooled, weight = 106 grams.	22.6	4288	969	440	13

* Omit word "cooked" throughout, in reading column headings, for this sample.

TABLE I—*Continued*

SERIAL NUMBER	MANIPULATION	WEIGHT 100 GRAMS RAW VEGETABLES AFTER BEING COOKED AND DRIED	CALORIE VALUE PER GRAM OF DRIED VEGETABLES	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER GRAM OF RAW WEIGHT	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER POUND OF RAW WEIGHT	CALORIFIC MATTER LOST IN COOKING
String Beans, I. Young green, purchased May 9; strung, cut into half-inch lengths						
		grams	*gram-calories*	*gram-calories*	*kilo-calories*	*per cent*
S. B. I, 1	Uncooked.*	10.16	3960	402	183	
S. B. I, 2	80 grams raw vegetable blanched five minutes in 500 grams salted distilled water (0.2-4 per cent salt), cold-dipped. Drained, cooled, 99 grams.	9.317	3750	349	159	13
S. B. I, 3	71 grams raw vegetable blanched five minutes in 500 grams boiling distilled water, cold-dipped. Drained, cooled, 92 grams.	8.43	4046	341	155	15
String Beans, II. Young green, purchased June 5; "strung" and cut into half-inch lengths						
S. B. II, 1	Uncooked.*	11.7	3768	441	200	
S. B. II, 3	80 grams raw vegetable boiled in 500 cc. distilled water (0.4 per cent salt) for twenty minutes. Drained, cooled, weight = 89 grams. (Not quite "done" enough to eat.)	10.16	3890	395	179	10
S. B. II, 4	87 grams raw vegetable steamed twenty minutes on wire gauze, 3 inches from level of boiling water; covered, but not perfectly tight. Drained, cooled, weight = 85 grams. (Not quite "done" enough to eat.)	11.52	3872	446	202	1+, (gain)†
S. B. II, 2	199 grams raw vegetable autoclaved in wire basket twenty-five minutes at pressures between 10 and 15 pounds; entire period of steaming in autoclave, forty-four minutes. Cooled, weight = 174 grams. Flavor unpleasant, like hay, otherwise tasteless; mealy texture.	11.04	3862	436	198	1

* Omit word "cooked" throughout, in reading column headings, for this sample.

† This apparent gain may probably be due to some error in determining the factor noted in the third column. The sample used for drying was an unusually small one. Or, it may be due to lack of homogeneity in raw materials.

TABLE 1—*Continued*

SERIAL NUMBER	MANIPULATION	WEIGHT 100 GRAMS RAW VEGETABLES AFTER BEING COOKED AND DRIED	CALORIE VALUE PER GRAM OF DRIED VEGETABLES	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER GRAM OF RAW WEIGHT	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER POUND OF RAW WEIGHT	CALORIFIC MATTER LOST IN COOKING
	String Beans, II. (*Continued*)					
		grams	*gram-calories*	*gram-calories*	*kilo-calories*	*per cent*
S. B. II, 5	159 grams raw vegetable in pint jar with 260 grams water and 1.7 grams salt, cover screwed down; cooked in autoclaved run as described in S. B. II, 2, above. Jar was opened fifteen minutes after removal from autoclave; temperature of contents, 90°. Drained and cooled, beans weighed 191 grams. Flavor of beans and of juice, fairly good; juice rather cloudy.	9.535	3785	361	164	18
	String Beans, III. Purchased March 18, 1918. Green, tender. "Strung," cut into ¾ inch pieces					
S. B. III, 1	Uncooked.*	9.863	3926	387	176	
S. B. III, 2	133 grams raw vegetable boiled thirty minutes in 700 cc. tap water; cooking water at end of process, 350 cc. Weight of beans after cooked, 150 grams.	6.646	4120	274	123	30
	Spinach, I. Purchased March, 1918. Somewhat stale. Not washed					
Spin. I, 1	Uncooked.*	8.636	3491	302	137	
Spin. I, 2	111 grams of raw vegetable steamed seventeen minutes on false bottom over 150 cc. water. Drained and cooled, 107 grams.	8.180	3257	266	121	12
	Spinach II. Purchased April, 1918. Fresh. Washed with ordinary care					
Spin. II, 1	Uncooked.*	8.235				
Spin. II, 2	205 grams boiled twenty-five minutes in 3000 cc. tap water (2200 cc. at close). Weight after cooled and drained, 168 grams.	5.200				
Spin. II, 3	200 grams steamed twenty-five minutes on wire gauze. Weight after drained, 169 grams.	7.450				

*Omit word "cooked" throughout, in reading column headings, for this sample.

TABLE I—*Continued*

SERIAL NUMBER	MANIPULATION	WEIGHT 100 GRAMS RAW VEGETABLES AFTER BEING COOKED AND DRIED	CALORIE VALUE PER GRAM OF DRIED VEGETABLES	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER GRAM RAW WEIGHT	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER POUND OF RAW WEIGHT	CALORIFIC MATTER LOST IN COOKING
Cauliflower, I. Half-pound head. Leafy bracts and petioles tender green. Head divided vertically						
		grams	*gram-calories*	*gram-calories*	*kilo-calories*	*per cent*
Caul. I, 1	Uncooked.*	14.24	3828	545	247	
Caul. 1, 2	55 grams raw vegetable boiled in 500 cc. tap water (150 cc. at end of period) for fifteen minutes. Cold, drained, weight = 52 grams.	10.26	4059	416	189	23
Caul. I, 3	50 grams raw vegetable steamed twenty-five minutes. Cold, drained, weight = 49 grams.	14.36	3773	542	246	0
Caul. I, 4	Outer leaf stalk only, uncooked.*	15.02	3702	556	252	
Caul. I, 5	Outer leaf stalk only, 25 grams raw stalk boiled in same water with Caul. I, 2, above, for twenty-five minutes. Cold, drained, weight = 25 grams.	11.60	3671	426	194	23
Caul. I, 6	Outer leaf stalk only, 15 grams steamed twenty-five minutes. Cold, drained, weight = 12 grams.	12.60				
Brussels Sprouts, I. A good fresh green. A little dry						
B. S. I, 1	Uncooked.*	17.055	4154	709	322	
B. S. I, 2	94 grams raw vegetable boiled whole, five minutes in boiling tap water (500 cc.). Cooled, weight = 108 grams	14.31	4246	608	276	14
B. S. I, 3	94 grams raw vegetable boiled whole twenty-five minutes in 500 cc. tap water. Cooled, weight = 112 grams.	10.96	4539	414	188	42
B. S. I, 4	97 grams raw vegetable, each head cut lengthwise into three or four slices, boiled twenty-five minutes in 500 cc. tap water. Cooled, weight = 120 grams.	14.41	4266	615	279	13

*Omit word "cooked" throughout, in reading column headings, for this sample.

TABLE 1—*Continued*

SERIAL NUMBER	MANIPULATION	WEIGHT 100 GRAMS RAW VEGETABLES AFTER BEING COOKED AND DRIED	CALORIE VALUE PER GRAM OF DRIED VEGETABLES	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER GRAM RAW WEIGHT	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER POUND OF RAW WEIGHT	CALORIFIC MATTER LOST IN COOKING
Cabbage, I. Purchased January, 1918. Firm, white head about $1\frac{3}{4}$ pounds. Outer leaves missing. No green. Cut vertically						
		grams	*gram-calories*	*gram-calories*	*kilo-calories*	*per cent*
Cab. I, 1	Uncooked.*	7.914	3803	301	137	
Cab. I, 2	188 grams raw vegetable (one-fourth of cabbage head), steamed thirty minutes. Weight, after cooked and cooled, 175 grams.	8.388	3763	316	143	4.4 (gain)†
Cab. I, 3	203 grams raw vegetable (one-fourth of head), cooked thirty minutes in 1000 cc. boiling tap water (700 cc. at end of cooking period). Weight after cooked and cooled, 215 grams.	5.835	4001	234	106	21
Cab. I. 4	180 grams raw vegetable (one-fourth of head), cooked thirty minutes in 1000 cc. boiling salted tap water (1.5 per cent salt); 750 cc. at end of cooking period. Cooked and drained, 167 grams. "Cooked to pieces" more than Cab. I, 3 (which was a more compact piece).	7.591	3335	253	115	14
Cabbage, II. Purchased November, 1917. Small, compact, crisp heads; outer leaves pale green. Cut vertically						
Cab. II, 1	Uncooked,* ground and dried.	10.00	3809	381	173	
Cab. II, 2	900 grams raw vegetable (one small solid head cut into eighths) blanched in 4500 cc. boiling tap water ten minutes, then cooled under running tap. Packed tightly into quart jar, with hot water and 10 grams salt. (57.5 grams remaining as juice at end of process.) Jar processed two hours in bath of boiling water. Weight of drained cabbage, 797 grams.	10.107	3664	371	168	3

* Omit word "cooked throughout, in reading column headings, for this sample.

† This discrepancy is, so far, unexplained.

TABLE I—*Continued*

SERIAL NUMBER	MANIPULATION	WEIGHT 100 GRAMS RAW VEGETABLE AFTER BEING COOKED AND DRIED	CALORIE VALUE PER GRAM OF DRIED VEGETABLES	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER GRAM OF RAW WEIGHT	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER POUND OF RAW WEIGHT	CALORIFIC MATTER LOST IN COOKING
	Cabbage, II. (*Continued*)					
		grams	*gram-calories*	*gram-calories*	*kilo-calories*	*per cent*
Cab. II, 3	Duplicate of Cab. II, 2, except not packed so closely. 276 grams of drained cabbage and 120 cc. liquid in pint jar. (375 grams of raw cabbage had been packed into it.)	5.7	3654	209	94	46
Onions, I.	Ordinary yellow. Purchased February, 1918. Outer scaly leaves rejected					
O. I, 1	Uncooked,* vertical halves of two onions. Control for O. I, 2.	8.075	3817	313	142	
O. I, 2	83 grams raw vegetable, vertical halves of same onions used for O. I, 1. Soaked twelve and one-half hours in 650 cc. water, after slicing horizontally (went all to pieces). Drained, weight = 104 grams. Bud swelled, unequal tissue strains apparent.	7.394	3783	280	127	11
O. I, 3	Uncooked,* lower half of an onion, same lot. Control for O. I, 4 (???)	11.89	3940	469	213	
O. I, 4	44 grams raw vegetable, upper half same onion as in O. I, 3. Soaked in 350 cc. salted tap water (two per cent salt) for twelve and one-half hours, having been cut into three horizontal slices. Held together fairly well; wilted, except for smallest inner bud. Drained, weight = 48 grams.	9.527	3585	342	155	27†
O. I, 5	68 grams raw vegetable, (1 onion), cut crosswise into halves. Boiled forty minutes in 1100 cc. tap water (700 cc. at end of period). Cooked and drained, weight = 58 grams. Cooking water concentrated, yielded 8438 kilo-calories.	4.421	4097	181	82	41

* Omit word "cooked" throughout, in reading column headings, for this sample.

† See p. 31 for discussion of comparison between O. I, 2 and O.I, 4.

TABLE I—*Continued*

MANIPULATION	SERIAL NUMBER	WEIGHT 100 GRAMS RAW VEGETABLES AFTER BEING COOKED AND DRIED	CALORIE VALUE PER GRAM OF DRIED VEGETABLES	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER GRAM OF RAW WEIGHT	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER POUND OF RAW WEIGHT	CALORIFIC MATTER LOST IN COOKING
Onions, I. *(Continued)*						
		grams	*gram-calories*	*gram-calories*	*kilo-calories*	*per cent*
	O. I, 6	50 grams raw vegetable (1 onion), boiled whole forty minutes in 1000 cc. tap water (700 cc. at end of cooking period). Weight, after cooled and drained, 41 grams. Cooking water concentrated, yielded 6878 calories.	6.868	3842	264	120	34
Turnips, I. White, purchased January 15, 1917; 290 grams each. Pared, quartered lengthwise, in T. I, 1 and 2						
	T. I, 3	Uncooked.*	5.29	3850	204	92	
	T. I, 1	61 grams raw vegetable cooked thirty minutes in 500 cc. boiling tap water. Weight, after drained and cooled, 57 grams.	3.761	4098	154	70	24
	T. I, 2	65 grams raw vegetable cooked thirty minutes in 500 cc. boiling salted tap water (1.5 per cent salt). Weight, after drained and cooled, 59 grams. (Water boiled almost dry.)	6.041	3283	198	90	2
Asparagus, I. Purchased March, 1918. Base of stems tough, trimmed off.							
	Aspar. I, 1	Uncooked.*	7.953	4068	324	147	
	Aspar. I, 2	76 grams blanched five minutes in 1000 cc. boiling tap water. Weight, after cooled and drained, 76 grams.	7.185	4139	297	135	8
Asparagus, II. Purchased May, 1918. Trimmed, washed							
	Aspar. II, 1	Uncooked.*	7.590				
	Aspar. II, 2	69 grams cut into 1½ inch lengths, blanched five minutes in 500 cc. boiling tap water. Weight, after drained, 71 grams.	7.597				

*Omit word "cooked throughout, in reading column headings, for this sample.

TABLE I—*Continued*

SERIAL NUMBER	MANIPULATION	WEIGHT 100 GRAMS RAW VEGETABLES AFTER BEING COOKED AND DRIED	CALORIE VALUE PER GRAM OF DRIED VEGETABLES	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER GRAM OF RAW WEIGHT	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER POUND OF RAW WEIGHT	CALORIFIC MATTER LOST IN COOKING
Parsnips, II.	Purchased January, 1917. Medium size, pared, cut lengthwise into eighths. Wilted					
		grams	*gram-calories*	*gram-calories*	*kilo-calories*	*per cent*
P. II, 8	Uncooked.*	26	3916	1018	462	
P. II, 7	Blanched five minutes in 1000 cc. tap water; cold dipped; 86 grams of vegetables cooked twenty-two minutes in 1000 cc. hot unsalted tap water; weight, after cooking, 83 grams.	17	4125	701	318	31
P. II, 6	Blanched in 1000 cc. salted distilled water ($\frac{7}{10}$ per cent salt) five minutes; cold dipped; 85 grams of vegetables cooked twenty-two minutes in 1000 cc. hot salted distilled water ($\frac{7}{10}$ per cent salt); Weight after cooking, 83 grams.	20	3941	788	357	23
Parsnips, III.	Purchased January, 1918. Medium size, badly wilted before used, pared					
P. III, 1	Uncooked.*	31.38	4450	1396	633	
P. III, 2	61 grams of raw vegetable (one half parsnip, cut lengthwise), cooked thirty minutes in 900 cc. boiling tap water. Weight, after cooked and drained, 68 grams. Control, P. III, 1.	26.57	3967	1054	478	25
P. III, 3	Uncooked* (second parsnip from same lot as P III, 1).	38.11	3912	1491	676	
P. III, 4	58 grams of raw vegetable cut crosswise from same parsnip as P. III, 3, alternately from top and tip; blanched three and one-half minutes in 500 cc. boiling tap water; weight after cooked and drained, 67 grams.	26.93	4013	1081	491	27
P. III, 5	50 grams raw vegetable, duplicate of P. III, 4, but cooked seven minutes in boiling tap, 500 cc. Weight, after cooked, 58 grams.	25.26	4027	1018	462	32

*Omit word "cooked" throughout, in reading column headings, for this sample.

TABLE I—*Continued*

SERIAL NUMBER	MANIPULATION	WEIGHT 100 GRAMS RAW VEGETABLES AFTER BEING COOKED AND DRIED	CALORIE VALUE PER GRAM OF DRIED VEGETABLES	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER GRAM OF RAW WEIGHT	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER POUND OF RAW WEIGHT	CALORIFIC MATTER LOST IN COOKING
Parsnips, IV. Purchased February, 1918. Medium size, mature, unwilted, pared						
		grams	*gram-calories*	*gram-calories*	*kilo-calories*	*per cent*
P. IV, 1	Uncooked.*	22.78	3858	879	399	
P. IV, 2	74.5 grams raw vegetable (one-half of same individual as P. IV, 1, cut lengthwise), cooked thirty-three minutes in 550 cc. boiling tap water (380 cc. at end of cooking period). Weight, after cooked and drained, 72 grams.	18.77	3989	749	340	15
P. IV, 3	33 grams raw vegetable (one-quarter of same individual as P. IV, 1, cut lengthwise). Cooked thirty-three minutes in 550 cc. boiling tap water (230 cc. at end of cooking period). Weight, after cooked, 32 grams	17.94	4118	739	335	16
P. IV, 4	Uncooked,* second parsnip from same lot as P. IV, 1. Sliced crosswise, slices taken alternately from top and tip.	21.42	3987	854	387	
P. IV, 5	58.5 grams raw vegetable, duplicate of P. IV, 4, cooked thirty-three minutes in 550 cc. boiling tap water (310 cc. at end of cooking period). Weight, after cooked, 55 grams.	13.45	4022	541	246	36
Carrots, I. Purchased January, 1917. Mature, medium size, pared, and sliced crosswise. (Dry, slightly wilted.)						
C. I, 8	Uncooked.*	21.4	3632	777	352	
C. I, 4	70 grams of vegetable put into 500 cc. cold distilled water; ten minutes coming to boil; boiled twenty-five minutes. Weight cooked, 55 grams.	8.1	3869	308	140	60

*Omit word "cooked" throughout, in reading column headings, for this sample.

TABLE I—*Continued*

SERIAL NUMBER	MANIPULATION	WEIGHT 100 GRAMS RAW VEGETABLES AFTER BEING COOKED AND DRIED	CALORIE VALUE PER GRAM OF DRIED VEGETABLES	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER GRAM OF RAW WEIGHT	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER POUND OF RAW WEIGHT	CALORIFIC MATTER LOST IN COOKING
	Carrots, I. *(Continued)*					
		grams	*gram-calories*	*gram-calories*	*kilo-calories*	*per cent*
C. I, 5	87 grams of vegetable put into 500 cc. cold distilled water; five minutes coming to boil; boiled fifteen minutes. Weight cooked, 77 grams. Water boiled away quite extensively. Not quite "tender."	12.0	3682	442	201	43
C. I, 1	92 grams of vegetable put into 500 cc. hot salted distilled water (1.5 per cent NaCl), cold dipped. Boiled thirty-two minutes. Weight cooked, 88 grams. Boiled gently, water level not much lowered at end of period.	13.0	2835	368	167	53
C. I, 6	83 grams of vegetable blanched seven minutes in 500 grams, salted distilled water (1.5 per cent NaCl), cold dipped; boiled twenty-two minutes in 500 cc. hot salted distilled water (1.5 per cent NaCl). Weight (cooked), 67 grams. Water boiled away quite extensively.	12.0	3117	374	170	52
	Carrots, II. Purchased April, 1917. Mature, pared, and sliced crosswise, unless otherwise designated. (Wilted somewhat.)					
C. II, 3	84 grams vegetable cooked thirty minutes in 500 cc. boiling distilled water. Weight, after cooked, 93 grams. Volume of water at end of process not observed.	9.29	3720	346	157	56
C. II, 4	18 grams vegetable (one fourth carrot sliced lengthwise) cooked thirty minutes in 500 cc. boiling distilled water. Weight, after cooked 30 grams.	15.44	3724	575	261	26

* Omit word "cooked" throughout, in reading column headings, for this sample.

TABLE I—*Continued*

SERIAL NUMBER	MANIPULATION	WEIGHT 100 GRAMS RAW VEGETABLES AFTER BEING COOKED AND DRIED	CALORIE VALUE PER GRAM OF DRIED VEGETABLES	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER GRAM OF RAW WEIGHT	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER POUND OF RAW WEIGHT	CALORIFIC MATTER LOST IN COOKING
	Carrots, II. (*Continued*)					
		grams	*gram-calories*	*gram-calories*	*kilo-calories*	*per cent*
C. II, 6	71 grams cooked vegetable which came from steam pressure institutional cooker. Pared and sliced crosswise before cooking as usual. Weight, before cooking, unknown.†	7.58	3638	276	125	65
	Carrots, III. Purchased May, 1917. Small, young, pared, and sliced crosswise					
C. III, 1	Uncooked.*	11.6	3597	418	190	
C. III, 2	54 grams vegetables boiled in 500 cc. hot distilled water for twenty-three minutes. Weight, after cooked, 57 grams.	7.002	3776	265	120	37
C. III, 3	62 grams vegetable steamed thirty minutes over 1000 cc. water. Weight, after cooked, 57 grams.	11.78	3646	416	189	0.95
	Carrots, IV. Purchased January, 1918. Medium size, pared, and sliced as described					
C. V, 1	Uncooked.* (Control for C. IV and C. V.)	10.8	3618	391	177	
C. IV, 1	39 grams vegetable cut into lengthwise slices, 10 grams each; blanched in 500 cc. boiling tap water, five minutes. Weight, after blanched, cold dipped and drained, 36 grams.	6.885	3788	268	118	33

* Omit word "cooked" throughout, in reading column headings, for this sample.

† Steam cooked vegetables usually lose weight in cooking, but it may be that these pieces were so situated that they took up some water (condensed steam) which washed over them. In calculating this sample, the raw weight has been assumed to be identical with the weight after cooking. If the weight of raw vegetable was greater than the weight cooked, then the cooking loss is still greater than here calculated; if less, then the loss would be somewhat less.

TABLE I—*Continued*

SERIAL NUMBER	MANIPULATION	WEIGHT 100 GRAMS RAW VEGETABLES AFTER BEING COOKED AND DRIED	CALORIE VALUE PER GRAM OF DRIED VEGETABLES	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER GRAM OF RAW WEIGHT	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER POUND OF RAW WEIGHT	CALORIFIC MATTER LOST IN COOKING
	Carrots, IV. *(Continued)*					
		grams	*gram-calories*	*gram-calories*	*kilo-calories*	*per cent*
C. IV, 3	34 grams vegetable cut lengthwise into strips of 10 grams each; cooked twenty-five minutes in boiling tap water, 500 cc. Weight, after cooked, 28 grams. Water cooked down to 180 cc. at end of cooking period	5.027	4035	203	92	48
C. IV, 5	72 grams vegetable cut lengthwise into 7 strips laid on wire gauze screening, autoclaved fifteen minutes at 15 pounds; total length of time in autoclave, thirty-seven minutes. Weight, after cooked, 55 grams.	8.714	3603	314	142	20
C. IV, 6	82 grams vegetable cut crosswise into 15 slices, autoclaved over wire gauze in same cooker and at same time as above. Weight, after cooking 61 grams. Surface exposed, considerably less than in C. IV, 5.	8.834	3598	318	144	19
	Carrots, V. Purchased January, 1918. Medium sized, pared, and sliced crosswise					
C. V, 1	Uncooked.*	10.8	3618	391	177	
C. V, 2	46 grams vegetable put into 500 cc. salted boiling tap water (1.5 per cent), cooked thirty-six minutes. Weight, after cooked, 32 grams.	12.4	2036	252	115	35
C. V, 3	51 grams vegetable put into 500 cc. unsalted boiling tap water, cooked thirty-six minutes. Weight, after cooked, 43 grams.	5.945	3725	222	101	43

*Omit word "cooked" throughout, in reading column headings, for this sample.

TABLE I—*Concluded*

SERIAL NUMBER	MANIPULATION	WEIGHT 160 GRAMS RAW VEGETABLES AFTER BEING COOKED AND DRIED	CALORIE VALUE PER GRAM OF DRIED VEGETABLES	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER GRAM OF RAW WEIGHT	CALORIE VALUE OF COOKED VEGETABLES, CALCULATED PER POUND OF RAW WEIGHT	CALORIFIC MATTER LOST IN COOKING
Carrots, VI. Purchased November, 1917. Fairly large, juicy; pared, and sliced crosswise						
		grams	*gram-calories*	*gram-calories*	*kilo-calories*	*per cent*
C. VI, 1	Uncooked.*	11.56	3643	421	191	
C. VI, 2	700 grams vegetable blanched six minutes in about 5000 cc. boiling tap water; cold-dipped, packed tightly into quart glass jar; spaces filled with boiling water, cover and rubber gasket adjusted; jar set into boiling water bath covering it. Time of process, two hours. Water bath boiled away somewhat, jar lost water, 2 to 3 inches space (and partial vacuum) above level of juice in jar when cold. Contents when opened, 699 grams of cooked and drained carrots, 283 cc. juice.	9.911	3546	351	159	18
C. VI, 3	Duplicate of C. VI, 2, from different jar, 700 grams raw carrots; cooked and drained, 672 grams, 300 grams (290 cc.) of juice.	8.024	3802	305	138	28

* Omit word "cooked" throughout, in reading column headings, for this sample.

It is, however, the more soluble, rather than the difficultly soluble or insoluble carbohydrates and salts, which are the measure of available food; therefore the food losses exceed rather than run below the percentage here stated.

3. The "blanching" process as ordinarily used in home canning, causes losses of 8 to 15 per cent (Peas II, 2, 3, 4; Aspar. I, 2; Spin. I, 2; Brussels sprouts I, 3; String beans, 1, 2, 3) and 27 to 33 per cent if vegetables are peeled and sliced (sliced parsnips, P III, 4 and 5). These peas were blanched for 6 minutes, the string beans and carrots for 5 minutes. The peas might have received a somewhat shorter blanch (2 to 4 minutes), which would reduce their loss somewhat, but not propor-

TABLE II

Losses in mineral salts due to cooking

SAMPLE	WEIGHT 100 GRAMS VEGETABLE AFTER COOKED AND DRIED	ASH IN DRIED VEGETABLE MATERIAL	ASH CALCULATED TO FRESH WEIGHT	ASH LOST IN COOKING
	grams	*per cent*	*per cent*	*per cent*
Asparagus II, 1, raw	7.590	8.33	0.63	
Asparagus II, 2, blanched five minutes	7.597	7.86	0.60	5
Beans, String, S. B. III, 1, raw	9.863	5.897	0.58	
Beans, String, S. B. III, 2, boiled thirty minutes	6.646	5.479	0.36	38
Brussels Sprouts, I, 1, raw	17.055	6.50	1.11	
Brussels Sprouts, I, 2, blanched five minutes	14.31	6.244	0.89	20
Brussels Sprouts, I, 3, boiled twenty-five minutes	10.96	5.10	0.56	50
Cabbage, I, 1, raw	7.786	7.27	0.57	
Cabbage, I, boiled thirty minutes tap	5.835	7.18	0.42	26
Carrots, II, 5, raw	14.21	10.51	1.46	
Carrots, II, 1, boiled thirty minutes	8.74	6.80	0.59	60
Cauliflower, I, 1, raw	14.24	9.04	1.29	
Cauliflower, I, 2, boiled fifteen minutes	10.26	6.91	0.71	45
Cauliflower I, 3, steamed twenty-five minutes	14.36	8.13	1.17	9
Onions, I, 1, raw	8.075	3.17	0.26	
Onions, I, 2, soaked twelve hours	7.394	3.07	0.23	12
Onions, I, 3, raw	11.89	4.70	0.56	
Onions, I, 6, boiled forty minutes whole	6.868	4.28	0.29	?
Parsnips, III, 3, raw	38.11	4.84	1.85	
Parsnips, III, 4, boiled three and one-half minutes	26.93	3.84	1.03	42
Parsnips, III, 5, boiled seven minutes	25.26	3.42	0.86	54
Peas, II, 1, green, raw	26.16	3.31	0.87	
Peas, II, 2, boiled in distilled water, six minutes	21.99	3.27	0.72	17
Peas, II, 4, boiled in tap water, six minutes	22.6	3.25	0.74	15
Spinach, I, 1, raw, unwashed*	8.636	23.66	2.04	
Spinach, I, 2, steamed seventeen minutes	8.180	24.2	1.98	2.94
Spinach, II, 1, raw, washed*	8.235	24.34	2.01	
Spinach, II, 2, steamed twenty-five minutes	7.450	16.55	1.26	37
Spinach II, 3, boiled twenty-five minutes	5.200	12.42	0.67	67

*The determinations on spinach were made on washed and unwashed lots, after reading Rubner's statement (Berl. Klin. Wchnschrft. Apr. 10, 1916) that, owing to the cook's custom of washing spinach on one side of the leaf only, a large part of the "ash" is sand which clings to the leaves. This may have been true of the spinach which he analyzed, which showed half of the dry matter to be ash.

tionately to the reduction in time of blanching, since the losses are relatively heavier in the earliest moments of the extraction period. (Compare Parsnips III, 4 and 5.) String beans, fresh prime stock, are often blanched even longer ($3\frac{1}{2}$ to 6 minutes or more) under trade conditions.

4. The losses in blanching might be somewhat decreased by the use of a salted water. In case of peas the loss decreases from 15 per cent in distilled water (Peas II, 2 or 4) to 8 per cent in a 1.5 per cent salt solution (Peas II, 3); for string beans, from 15 per cent for distilled water (S. B. I, 3) to 13 per cent for 0.25 per cent salt solution (S. B. I, 2) or 10 per cent loss on 20 minutes' boiling in 0.4 per cent salt solution (S. B. II, 3). Stronger solutions could well be used when short cooking is given. Here a slight increase in strength of salt solution has made more difference in amount extracted than has a fourfold increase in time. In case of longer boiling "until tender," the decreases in fairly comparable samples are: Parsnips, from 31 per cent in tap water (P II, 7) to 23 per cent (P II, 6) in 0.7 per cent salt solution; white turnips, from 24 per cent (T I, 1) to 2 per cent (T I, 2) in 1.5 per cent salt. See also Cabbage, 1, 3, and 4.

Boiled in a small amount of salted water, or in water which eventually boils down to a small amount, the losses are still smaller. See C VI, 2—only 18 per cent loss, though they went through a 6 minutes' blanch before this long cooking period of several hours very near the boiling temperature. See also Peas I, 2, in which the salted water was entirely taken up; they apparently show less than 1 per cent loss, though they went through a 4 minutes' salt blanch before cooking.

The difference in extractive power between distilled and tap water (Lake Michigan at Chicago), is evident but not great enough to be of practical significance (Peas II, 2 and 4).

In comparing Onions I, 2 and 4, it should not be too hastily concluded that the effect of salt has been to increase the extraction. Unfortunately O I, 4 contains only the upper half of the bulb, and this may easily have been before soaking considerably lower in sugar than was the lower half (O I, 3) from which the amount of extraction is estimated.

5. Cooking losses are, of course, still further decreased by cutting the vegetable into large instead of into small pieces, particularly so if the cut runs parallel with fibro-vascular bundles rather than across them. Compare P II, and P III, 2, with P III, 4 and 5; $3\frac{1}{2}$ to 7 minutes extract as much from the cross-cut parsnip as do 30 minutes (or 27 minutes) from the lengthwise-cut parsnip.

6. Steaming, if properly performed, results in losses so small as to be ordinarily quite devoid of significance (Caul. I, 3; Spin. I, 2, table II,—but see also table I; Cab. I, 2; S. B. II, 4; C III, 3); this may be the case, even when the temperature is so high and the process so greatly prolonged as to result in serious detriment to flavor, as is possible in high pressure cooking (S. B. II, 2). However, this considerable period of steaming at higher temperatures than the boiling point is likely to extract a considerable amount of soluble material, when this is abundantly present (C IV, 5 and 6). Again, if the arrangement is such that steam condenses and water washes down over the heated vegetable tissue, the losses may be as great as in any other possible method of treatment (C II, 6); this is true in steamers of the household type as well as in those of institutional type, as those who may have seen the yellow water under steaming squash or pumpkin can testify.

7. It is obvious that extraction of soluble constituents will depend largely upon length of the period of cooking (e.g., P III, 4 and 5, C I, 4 and 5), and upon relative proportions of water and vegetable (e.g., compare P II, and P III, with P IV), especially as the cooking process nears its end and the water boils away more or less rapidly according to the rate at which heat is applied; e.g., compare C I, 1 with C I, 6 (differing amounts of water at close). These two factors are widely variable and exceedingly uncertain, in ordinary household practice, as is also the relative surface exposed, when the vegetable is cut or pared. Add to this the varying degree of extraction possible with different vegetables, owing to the different proportions of readily soluble carbohydrate and salts which they contain, and it will be seen that there is no possible universal factor which can be applied, in dietary calculations, to show losses of fuel or other values of foods, incurred in cooking; or none which can lay claim to the slightest approximation to accuracy upon all occasions.

Such statements as, "Boiling extracts three-fourths of the iron in spinach," or "one-fourth of the salts of potato" or "two-thirds of the sugar of carrots" may fit one instance precisely and yet be far from the truth in another.

Naturally these generalizations do not apply to the "conservation" methods of cooking (steaming, baking, boiling in jackets, utilization of vegetable stocks as soups or sauces) where the loss is reduced to practically nothing at all. One of the best of these economical methods is that in which the edible portion of the vegetable is cut fine and cooked

in a small amount of water or milk which is almost entirely absorbed, and which consequently is served with the vegetable. This cooking may be done directly over the flame, or on a hot plate of asbestos or heavy metal, or on the back of the range, or in a double boiler. The hard, sweet core of young cabbage heads, heated 15 to 30 minutes in this fashion, is a very different product from that which has been long boiled in water. The same thing is true of the outer stalks at the base of a head of cauliflower, which, though often discarded as refuse, apparently may have a higher food value than the fleshy part, and one as easily extracted as that of the fleshy floweret which is usually eaten. (See Caul. I, 1 and 4.)

It is also evident that preliminary soaking in cold water, or starting the cooking process in cold instead of in boiling water, will greatly increase cooking losses by prolonging the period of cooking, and by adding the extractive power of the water at lower temperatures to that at boiling temperature. (C I, 4 and 5; O I, 2 and 4.)

8. When steamed, all vegetables lose weight, mostly because of evaporation of water. (C III, 3; C IV, 5 and 6; S. B. II, 4; Caul. I, 3 and 6; Cab. I, 2; Spin. I, 2 and II, 3.) When boiled in an open dish in excess of water, a starchy, or dry, or wilted vegetable, or one with air spaces which can become waterlogged, or one unusually high in crystalloids (salts and sugars, which increase osmotic powers of the tissues), will take up water enough to gain in weight, even though it may have lost considerable amounts of solid matter (Pars. III, Car. II, green peas, string beans, Brussels sprouts). But a juicy or watery vegetable, or one protected by impermeable cuticle, loses water as well as solids, even when boiled in water, due no doubt to disturbances of colloidal systems within the tissues by the application of heat. The ease with which juice flows from heated meat or fruit (or from heated protoplasmic structures seen under the microscope) is a matter of common observation, as is the dryness of boiled meat in comparison with properly roasted meat. Again, a sound potato, boiled in its unpierced jacket, almost always loses a little in weight; and often a slight accumulation of water may be perceived underneath the skin, before it has succeeded in escaping. Vegetables cooked in salted water (see Peas, Turnips, Cauliflower, Cabbage) tend to lose weight more strongly than do those cooked in distilled or tap water; the strong solution outside the tissues draws water out of them by osmosis, as does salt on meat, or sugar on berries. Soaking vegetables in cold distilled or tap water,

however, swells them but does not cause heavy loss of solids (Onions I, 2), since the protoplasm is not killed and is able to retain its solutes to considerable degree for a time, at least before bacterial action shall have made itself felt.

It is evident, then, that a comparison of weights before and after cooking can give no information as to the extent of loss of solids. Yet we sometimes hear the commercial canners using this line of argument, in denying that losses take place in blanching. But the circumstance that young peas may show no increase in weight during blanching, does not prove nor indicate that no loss of salts, sugar, or protein of the pea, takes place.

9. It may be readily observed in case of a well-packed jar that the processing method used in home canning of vegetables or fruit submerged in a boiling water bath results in the presence of a minimum amount of juice in the jar. In Cab. II, 2 and 3, the combined weight of vegetables and brine or juice is less than the original weight of raw vegetable. In S. B. II, 5, there is an excess of water, due partly to the fact that there were not enough beans on hand to fill the jar, but also to the different method of canning, that of cooking with pressure steam while the jar is completely sealed, thus preventing any escape of liquid.)

This small amount of juice is a very different condition from that which sometimes has obtained in commercially canned goods. While due chiefly to differences in closeness of pack, it is also due to the fact that during the two or three hours of processing in boiling water bath the contents of the partially sealed jar are continually giving off steam to the water bath (even when the bath completely submerges jar and cover), or to the atmosphere above it, in case submersion is incomplete. The constantly escaping stream of air and steam bubbles, over or under the rubber gasket, can readily be observed during the entire period of processing. When the jar is lifted out of the bath, presumably the operator at once makes the seal tight; and, even though the seal should perhaps not chance to continue absolutely tight during the process of cooling, there is more or less vacuum remaining until the jar is opened, in a successful product which "keeps" well. The smaller amount of water or juice in the jar, then, may have only a moderate or even a relatively low extractive value, in spite of the long boiling period. Furthermore, the flavor of this juice is good, and it can be served with the vegetable, which is often not the case with jars or cans containing a large amount of watery juice in metal containers.

We may conclude, then, that the methods for home canning, as practiced in following the directions issued by extension workers in agriculture and home economics, U. S. Dept. of Agriculture, compare very favorably with other methods of canning as to effect upon nutritive value of product, *provided pains be taken to reduce losses from the blanching process.* This precaution is particularly important in case of young tender peas, carrots, corn, vegetables of the cabbage and onion families, and any vegetables pared and cut or broken into shreds or short lengths before blanching.

It is clearly of the greatest importance (as has been so often demonstrated) that the juice of vegetables escaping into cooking water should be conserved, and methods of making this juice palatable deserve the cook's attention. If onions must be boiled in excess of water to reduce their flavor, at least this water may be concentrated by boiling until it can furnish a suitable flavor for milk or cream soups, or broths or sauces, for vegetable or meat hash or stew, or loaf or croquettes.

A great deal of trouble has been taken to discover the best method of cooking each cut and kind of meat so as to secure optimum results. It is time that vegetable cookery received a larger share of attention from the average woman. The problems which arise in the cooking of each kind of vegetable should be given attention on their own merits. General directions for the cooking of the different classes as underground tubers and root stocks, green vegetables, etc., are exceedingly useful, yet further details appropriate to each occasion should not be forgotten. Here is one small illustration concerning a point too often overlooked: When some parts of a vegetable are very much tougher and more resistant than others the two should not as a rule be cooked together until the toughest part is "done," for this is likely to destroy the more delicate flavor of the tender parts. We do not expect to cook the tenderloin strip and the tail piece of a porterhouse steak successfully by the same process; or if this is done, the tougher pieces are finely chopped before cooking, and this reduces the extra time needed. Often the same method of procedure can be used with vegetables. It is a clear waste, in time of high prices, to throw away the leaf petioles of kohlrabi or cauliflower, the central core of young cabbage or parsnips; very likely these have as high a soluble carbohydrate value as does the remainder of the vegetable. If grinding or chopping be substituted for a portion of the cooking process, or if these more resistant parts can be given a separate long slow cooking in fireless cooker or double boiler, then the palata-

bility of the combination may be greatly enhanced, and its nutrients conserved.

One word remains to be said, from the standpoint of modern theories of nutrition. Indications are not lacking that we may at last come to believe that spring "rheumatism" and pallor and skin disturbance; those cases of pyorrhea which are akin to what has sometimes been called scurvy, low resistance to many winter infections, and that common evil, constipation, can conceivably be favorably affected by such an increase in the diet of these vegetable salts, acids (and possibly "vitamines"), as occurs when we change from a winter diet of canned and heavily extracted vegetables to a spring diet of fresh or lightly cooked ones.[27] At least it seems worthwhile to take measures to prevent our foods from being depleted of these vegetable extracts which should no more be thrown away than should the drippings of fat and juice which cook out of meat. Yet many a woman, who would be shocked at the idea of throwing away a meat broth, does not hesitate to discard a much more highly nutritious vegetable broth.

Since the above words were written a study has appeared (Jour. Amer. Med. Assn., March 30, 1918) which exactly illustrates the point in view. Dr. Hess, a notable authority on scurvy, rickets, and other phases of pediatrics, considers it likely that the rickets, so commonly occurring among negroes in New York City, may have some relation to the lack of fresh vegetables and fruits in the diet. He finds that these emigrants from the West Indies never have the disease while living where the diet contains large amounts of fresh vegetables and fruits.

SUMMARY

1. Boiled vegetables may lose as low as 15 per cent or as high as 60 per cent of their fuel value, according to the method of manipulation. (Those vegetables which are cooked within their own heavy, intact jackets, such as unpeeled Irish potatoes and beets, will of course lose much less even than this minimum.) The extent of the loss depends upon the amount of soluble carbohydrate and protein present in the vegetable tissues, as well as upon the manipulation.

2. Losses in salts and nitrogen often, if not always, slightly exceed the fuel or caloric losses.

[27] It is of great interest and pleasure to the first holder of the Ellen H. Richards Fellowship, at the University of Chicago, who writes these lines, to learn that this doctrine was vigorously propagated by that wise and far-seeing woman.

3. Blanching for 5 or 6 minutes causes losses of 8 to 15 per cent (salts, fuel value). Peeled and sliced vegetables lose twice as much.

4. Salting the water (1.5 per cent solution, or about 1 tablespoon to the quart) decreases the losses in fuel value due to boiling.

5. Cutting the vegetable crosswise instead of lengthwise, or into small instead of large pieces, increases the losses.

6. Steaming usually cuts the caloric losses down almost to zero; also the salt losses, except in case of leafy tissues which expose a very large amount of surface to the action of the condensing vapor (cabbage, spinach). However, if conditions within the steamer are such that water washes down over the vegetable mass, steaming may cause very large losses. Particularly is this the case with pressure steamers.

7. The two factors most potent in causing variations in cooking losses are varying lengths of time of cooking, and varying amounts of water used in proportion to mass of vegetables to be cooked.

8. Steamed vegetables always lose in weight. Boiled vegetables may gain in weight because their intercellular spaces take up water at the same time that they are losing heavily in mineral salts and soluble carbohydrates and proteins.

9. Home canning often results in a maximum amount of vegetables and a minimum amount of watery juice in the jar, partly because of close packing and partly because liquid is driven off during the period of processing with seal only partially made. This relatively small amount of juice in the jar is a great advantage from the standpoint of true nutritive economy,—whatever may be its effect upon ease of sterilization of the vegetable mass.

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